Kepler Guest Observer Cycle 1 Selected Research Program

Photometry of an Eclipsing System with a White Dwarf Component, the Only One Known in the Kepler FOV
Dr. Roi Alonso, Laboratoire d'Astrophysique de Marseille

Abstract: Observations of the only known white dwarf with a M star eclipsing component that is accessible to Kepler may make this target the cornerstone of its class. We propose 1-min cadence observations of this post-common-envelope object to 1) obtain very precise orbital parameters, 2) study unsolved issues related to the flare activity on the M companion, 3) investigate the evolution and overall distribution of magnetic active regions in any of the components, 4) search for the secondary eclipse that serves to constrain the eccentricity of the system, 5) perform a study and interpretation of the O-C residuals of the 1040 eclipses/year to be obtained with unprecedented precision of 5~s/eclipse, and 6) search for pulsations of the WD component.

Starspot Evolution on Active Late-type Stars in the KEPLER Field
Dr. Alexander Brown, University of Colorado

Abstract: Starspots on late-type stars are a direct manifestation of the photospheric emergence of strong dynamo-generated magnetic fields. We propose to use Kepler to study the starspot variability on 135 active stars that we have indentified from GALEX FUV+NUV imaging, and investigate how activity phenomena such as the growth and decay of starspots, differential rotation, activity cycles, and flaring operate on single and binary stars with a wide range of mass (and hence convection zone depth). This will hopefully allow us to constrain models of magnetic field generation and transport in the fast rotation regime which any successful dynamo theory must be able to address.

Light Curves and Masses of AGN in the Kepler Field of View
Dr. Michael Carini, Western Kentucky University

Abstract: The Kepler mission will stare at the same patch of the sky for its entire mission lifetime, allowing virtually uninterrupted optical observations of any object in its field of view. This provides the opportunity to obtain optical light curves of AGN of unprecedented duration and sampling. I propose to use the unique capabilities of KEPLER to observe 2 AGN in its field of view and obtain the highest time resolution and longest continuous optical light curve of any AGN to date. The two sources I propose to observe are ZW 229.015 and IGR J19473+4452. ZW 229.015 is a V=15.4 Seyfert 1 galaxy at a redshift of 0.028 and IGR J19473+4452 is a B=15.7 Seyfert 2 galaxy at a redshift 0.054. Neither source has ever been the target of variability studies at any wavelength. For ground based optical astronomy, the limitations to time series analysis of light curves have always been sampling, duration and quality of the data. The Kepler mission allows us to overcome those limitations by providing continuous, high time resolution optical light curves over timescales sufficient to determine the power density spectrum (PDS) break frequency. The break frequency represents a characteristic variability timescale that is related to the mass of the SMBH. The resulting time series will also be analyzed for the presence of any periodic oscillations in the observed light curve. Such oscillations can be used to infer the mass of the central SMBH, assuming they arise from processes on the accretion disk. The timescales of the fastest discrete events will also be used to set upper limits to the smallest emission regions present (regardless of location) via light travel time arguments. This proposal fulfills the NASA strategic goal of understanding phenomena near black holes and the origin and destiny of the universe.

A Search for Companions to Intermediate Mass Binary Stars
Dr. Douglas Gies, Georgia State University Research Foundation

Abstract: There is abundant evidence that stellar companions are more commonplace among the more massive stars, but it is unknown whether or not the high frequency of companions extends to low mass stars and planets. Our goal in this proposal is to search for evidence of companions surrounding close eclipsing pairs of intermediate mass F- through B-type stars. Since these close binaries have periods of a few days, the search will focus on dynamically stable outer companions with orbital periods in the range 1 to 12 months. We will use precise light curves from Kepler of some 20 binaries to measure accurate eclipse timings, and we will search for companions by investigating periodic variations in the times of minima caused by the light travel time across the orbital displacement of the close binary. In favorable situations, we will be able to detect the presence of objects as small as gas giant planets. This work will begin the census of planets and other low mass companions around close binaries and more massive stars.

A Search for Hybrid Gamma Doradus/delta Scuti Pulsating Variable Stars
Dr. Joyce Guzik, Los Alamos National Laboratory

Abstract: The delta Scuti and gamma Doradus variables are main sequence (core hydrogen-burning) stars with masses somewhat larger than the sun (1.2 to 2.5 solar masses). The gamma Dor stars, having cooler effective temperatures, are pulsating in nonradial gravity modes with periods of near one day, whereas the delta Sct stars are radial and nonradial p-mode pulsators with periods of order one hour. Because of the near one-day periods of gamma Dor stars, satellite observations over a few weeks are preferred to ground-based single sites or networks to find multiple periods in these stars. Theoretically, gamma Dor and delta Sct pulsations would not be expected to co-exist. The gamma Dor g-mode pulsations are explained by a convective blocking mechanism that produces pulsation driving at the base of an envelope convection zone extending to temperatures of several hundred thousand Kelvin. The delta Sct p-mode pulsations are explained by driving in the helium ionization region in the envelope at about 50,000 K by increased opacity in this layer regulating radiation diffusion (the kappa effect). The kappa effect should not operate in the convection zones of gamma Dor stars, as convection instead of radiation is efficiently transporting the star¿s energy outward. Nevertheless, about half of the gamma Dor stars lie just within the theoretical delta Sct instability strip, and a few hybrid gamma Dor and delta Sct pulsators have been reported. Rowe et al. (2006) report on BD+18 4914, a hybrid pulsator discovered by space-based photometry using the MOST spacecraft. We propose to observe several stars accessible by Kepler with effective temperatures and abundances near the boundary of these two variable star types that are promising candidates for hybrid pulsators. With a year of photometric monitoring, a number of p- and g-mode frequencies that are ubiquitously predicted in main-sequence A-F stars could be determined. With enough modes, we could use asteroseismology to provide constraints on the internal structure of these stars, and learn more about how these two types of pulsations could coexist. It is likely that asteroseismology of such stars will lead us to a better understanding of the physics of time-dependent convection, opacities, and helium and element diffusive settling."

Measuring the Masses and Radii of the Lower Main Sequence: Identification of New Eclipsing M Dwarfs
Dr. Thomas Harrison, New Mexico State University

Abstract: We propose to use Kepler to search for new, low-mass main-sequence eclipsing binaries. Recent studies of eclipsing low-mass stars have shown that the radii of late-type dwarfs are consistently 10-15% larger than predicted by stellar models. The cause for this might be enhanced activity due to their binarity. If so, such an affect should diminish with increasing semi-major axis. Unfortunately, only a single system has a period > 3 days, thus this hypothesis cannot be tested. What is needed are additional eclipsing low-mass dwarfs. We restrict our target list to 15 < g < 18 to avoid overlap with the reserved list, while greatly expanding the number of potential late-type binary systems by surveying to larger distances. We will use NMSU resources at Apache Point Observatory to obtain follow-up photometry and spectroscopy to determine the fundamental parameters of the components in each system. We will also put to good scientific use all data gathered on targets that turn out to be single stars.

Kepler Observations of a Uniquely Varying White Dwarf System
Dr. Jay Holberg, University of Arizona

Abstract: We propose to observe a uniquely varying white dwarf system (BOKS 53836) recently discovered within the Kepler field. It was found in the Burrell-Optical-Kepler Survey as a blue object with a low amplitude light curve (0.04 mags) having a period of 0.255 days. There are strong reasons to believe that this system consists of a hot white dwarf star and a substellar companion; either a brown dwarf or a large Jupiter-like planet. Kepler observations of this very rare type of system are requested to accurately measure the light curve of this system. The suspected origin of the light curve is a reflection effect produced by light from the white dwarf on the atmosphere of the companion. Kepler data can confirm this and provide the high quality light curve which the effect can be physically modeled thereby shedding light on the nature of the companion, in particular its radius. Kepler data will also reveal any evidence of transient effects such as ¿stellar¿ activity or mass transfer associated with the secondary body.

Placing Kepler Magnitudes on an Absolute Photometric Scale
Dr. Jay Holberg, University of Arizona

Abstract: We propose to use Kepler to search for new, low-mass main-sequence eclipsing binaries. Recent studies of eclipsing low-mass stars have shown that the radii of late-type dwarfs are consistently 10-15% larger than predicted by stellar models. The cause for this might be enhanced activity due to their binarity. If so, such an affect should diminish with increasing semi-major axis. Unfortunately, only a single system has a period > 3 days, thus this hypothesis cannot be tested. What is needed are additional eclipsing low-mass dwarfs. We restrict our target list to 15 < g < 18 to avoid overlap with the reserved list, while greatly expanding the number of potential late-type binary systems by surveying to larger distances. We will use NMSU resources at Apache Point Observatory to obtain follow-up photometry and spectroscopy to determine the fundamental parameters of the components in each system. We will also put to good scientific use all data gathered on targets that turn out to be single stars.

Measuring the Sub-Millimagnitude Frequency Spectra of Pulsating B Stars
Dr. Bernard McNamara, New Mexico State University

Abstract: We propose to measure the pulsation spectra of 122 B-stars whose magnitudes are brighter than 15. Simulations show that Kepler 30 minute measurements over a 6 month time period will allow pulsations whose amplitudes are only 0.02 mmag to be detected with a S/N of about 6. This represents an improvement of a factor of over 60,000 relative to what has been achieved in the best ground-based studies of these stars. To demonstrate the value of these newly acquired spectra, we will determine the modes of the larger amplitude pulsations of three of these stars using multi-color light curves. The tools of asteroseismology will then be applied to the other Kepler frequencies to determine the masses, ages, metal content, convective overshoot parameter, hydrogen content, radii, surface rotation, and rotation profile for these stars.

Defining the Dependencies of Rotation for Old Cool Stars
Dr. Søren Meibom, Smithsonian Astrophysical Observatory

Rotation is a fundamental observable characteristic of a star and of its evolution, and the basis for stellar magnetic activity. It can even tell us the age of a cool main sequence field star in a distance-independent way. Consequently, it is imperative to develop our knowledge of stellar rotation, not only from the Kepler viewpoint of deriving ages for planet host stars, but also from a general astrophysical perspective. Prior ground-based work has shown that stellar rotation periods are essential to this development, rather than v sin i measurements. It is particularly useful to obtain them in open clusters, whose stars are coeval, because this fixes one of the two most important dependencies of rotation (age), the other one being mass. However, the precisions of ground-based observations are inadequate to measure rotation periods in intermediate age or old clusters. Accordingly, no rotation periods are available for coeval populations of stars between 600 Myr (Hyades) and Solar age. Luckily, the Kepler Field contains a 2.5 Gyr-old cluster, NGC 6819, which we have been studying intensively over the past decade. This (ongoing) work includes radial velocity membership and binarity information, and has already identified ~500 members of NGC 6819. We have chosen 134 of the most isolated members in the field of NGC 6819 as targets for the derivation of rotation periods from the Kepler data. Our team is prepared to undertake special efforts to extract the results beyond the analysis of the pipeline-produced light curves. By taking advantage of Kepler's superb precision, cadence, and duration, we will leap forward in our understanding of stellar rotation by measuring the relationship between stellar rotation, age, and mass to 2.5\,Gyr. Specifically, we propose to empirically define the period-mass-age surface for intermediate age stars by measuring 134 FGK dwarfs in the 2.5 Gyr old cluster NGC 6819."